Bell System Sleet Storm Map

By J. N. KIRK

MANY, no doubt, have seen copies of the Bell System Sleet Storm Map which has been prepared to show the relative intensities and frequencies of sleet storms throughout the United States. In the midst of the current sleet storm season it may be of interest to discuss some of the factors which have led to the preparation of this map, and to outline in a general way, the means by which its indications are utilized in the design, construction and upkeep of the pole and aerial wire plant.

A sleet storm to be destructive to telephone plant must be accompanied by such atmospheric conditions as will cause either a relatively heavy deposit of ice with no wind or a deposit of ice with a considerable amount of wind. It is neither difficult nor expensive to construct the aerial plant so that it will withstand winds of relatively high velocities provided the wires are free of sleet. A slight deposit of sleet, however, rapidly increases the "sail area" against which the force of the wind is directed and the resulting load constitutes one of the most formidable and most difficult to anticipate of any of the destructive agencies with which wire using companies have to contend. Maintenance difficulties unfortunately, are not necessarily at an end with a lessening or cessation of the wind, for this change may often increase the precipitation of sleet, which undisturbed by the wind builds up around the wires, frequently stressing them beyond the breaking point. It is not uncommon for a wire of approximately 1/10 of an inch in diameter to accumulate sleet or ice under favorable atmospheric conditions to the extent of a cylindrical coating from one to two inches or more in diameter. Some idea of the destructive effects of such ice loads upon both poles and wire may be gathered from Fig. 1 in which ice coatings as much as 2½ inches thick without wind were responsible for practically a complete collapse of the pole and open wire plant.

Any medium through which information on the past performance of pole and wire plant when subjected to storm conditions, may be collected, analyzed and arranged in convenient form for reference is a very valuable aid in the design and construction of new plant which may be subjected to similar conditions. It would be both impracticable and uneconomical to attempt to design open wire pole lines to withstand such loads as are imposed by the occasional and unusual storm, such for example, as was responsible for the damage

indicated in Fig. 1. It is, however, possible with proper data available to economically design the telephone lines so that they will withstand the more frequent storms of an average severity pertaining to the areas in which the lines are to be located. In predicting such average storms in different localities, a sleet storm map reflecting past performance as to storms and resulting damage is of material assistance.

In 1911 arrangements were made to collect data relative to sleet storms occurring in the territories of the various Associated Companies and to graphically indicate the cumulative results of such data

Fig. 1

with particular reference to the intensity and frequency of the storms recorded. In so far as possible the collection of these data was made retroactive so that, at least for those sections of the country where storms of a destructive nature had occurred, it was possible to start with an accumulation of reasonably accurate past performance data to which has annually been added very carefully collected information with regard to all subsequent storms of consequence. These data have made possible the preparation of a map, Fig. 2, in which the cumulative effect of storms extending over a considerable period of time is shown by various colors, markings and groupings of pins in such manner that for relatively large areas the future storm exposure to which the telephone plant is likely to be subjected, is indicated.

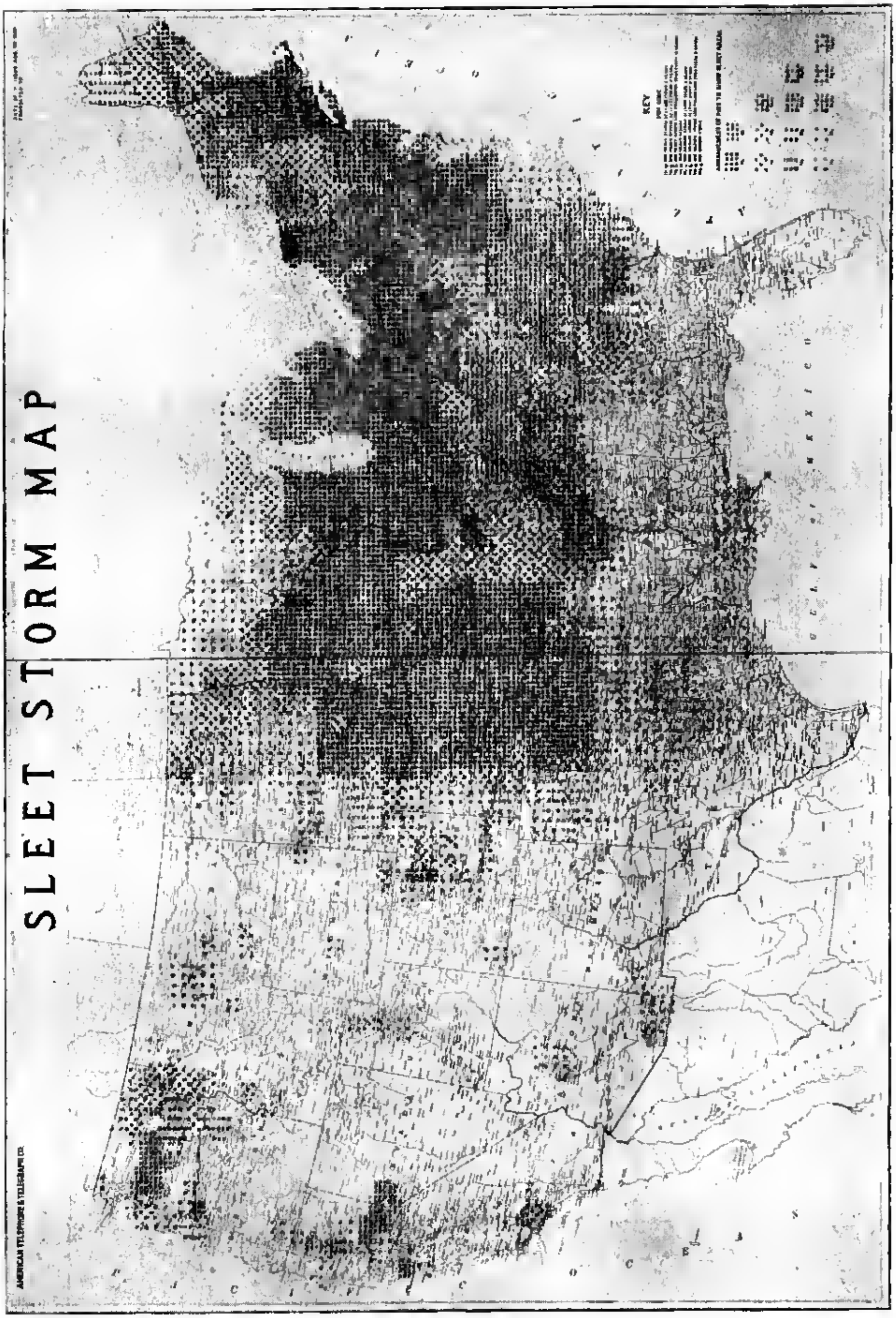

Fig. 2

A particularly important feature of this map in so far as its application to the design of telephone plant is concerned, is that it represents actual destructive effects upon existing telephnne plant and is not directly governed by the extent of precipitation measured by the Weather Bureau nr otherwise, which in certain areas may have been very heavy but from which no destructive effects were experienced.

For convenience in preparing and interpreting the sleet storm map, all storms have been classified as either heavy or medium and the frequency of their occurrence has been considered in four sub-divisions. The heavy storm was defined as one in which the diameter of the ice covering the wires was 3/4″ or greater and is represented on the map by the dark pins. The medium storm was defined as one in which the diameter of the ice covering the wires was less than 3/4″ yet sufficient to cause appreciable damage to the aerial plant, and is represented on the map by the light pins. In certain cases where the thickness of ice was not recorded, sleet storms have been classified by the amnunt of damage caused, commensurate with storms in which the ice deposit was known.

The four sub-divisions of storm frequency considered are represented by different markings and groupings of the pins corresponding to the class of storm experienced, light marking being used on the dark pins and dark marking on the light pins. At least one storm every three years is represented by unmarked, closely spaced pins; at least one storm every six years is represented by a single mark across the face of the pins the latter being more widely spaced and staggered; and storms occurring less frequently than every six years are represented by a cross on the face of the pins which are more closely spaced vertically than horizontally on the map. The fourth subdivision is in the nature of an exception to the third in that it covers those cases in which only one storm has been recorded. These single storms are represented by a single dot on the face of the pins, the latter being widely but evenly spaced. These various arrangements may occur singly or in combination resulting in the differently shaded areas presented by the map shown in Fig. 2. No shading or markings appear in those areas in which no sleet storms have been reported either because no aerial plant is maintained or because that area does not experience sleet.

The effect of the wind has been taken into consideration in the preparation of the sleet storm map only when such consideration would change the classification of the area involved. In the design of the aerial plant, however, the horizontal force exerted by the wind on the wires and therefore on the poles, is an important factor. For

convenience in engineering studies and in the design of the pole and wire plant the country has been divided into areas according to three intensities of storm loading, designated as heavy, medium and light. Although not defined by the same limits, these classifications for all practical purposes agree with the relative severities indicated by the sleet storm map.

The heavy storm loading as used in engineering studies is defined as the load caused by a 1/2″ radial deposit of sleet on the wires, strand, etc., combined with a horizontal wind exerting a pressure of 8 pounds per square foot upon the projected areas of cylindrical surfaces. The medium storm loading is defined as 2/3 of the heavy loading. The light storm loading is defined as 2/3 of the medium or 4/9 of the heavy and is in general considered as applying to those areas in which no appreciable sleet storm damage has been recorded. This so-called light loading is, however, in the case of small wires such as those used in telephone plants, considerably in excess of the load created by high wind velocities with no sleet deposit.

The effective wind pressures used in defining these storm loadings are considered as being produced by steady winds of uniform velocity. The dynamic forces and cumulative loads which might be developed by sudden gusts of wind and vibration of the line are not considered because experience has indicated that aerial plant designed to withstand the more readily determined static forces is satisfactory.

A brief discussion of the effect of various sleet and wind loads upon the tension in telephone wires will emphasize the value of information as to probable storm loads, in the design of the aerial wire and pole plant.

Design of the Wire Plant

In the design of the wire plant the horizontal component and the vertical component of the storm load must be considered. The weight of the ice covered wire represents the vertical component. The wind pressure upon the projected area of the ice covered wire represents the horizontal component.

The curves in Fig. 3, show the relative magnitude of the loads upon the wires caused by (a) winds of various velocities with no sleet on the wires, (b) various ice coatings with no wind, and (c) the combination of an 8-pound (73.6 miles per hour indicated velocity) wind with the same ice coatings as in (b). These curves indicate that the wind exerts a relatively small load upon the wire plant even at high velocities and that the load caused by ice accumulation increases very rapidly as the radial coating of the ice increases.

Design of the Pole Plant

A pole is subjected to vertical and transverse loads. The vertical load comprises the combined weights of the pole, crossarms, wires and any snow and sleet that may adhere to them. The transverse load is considered to be caused by a horizontal wind pressure upon the projected area of pole, crossarms and ice covered wires.

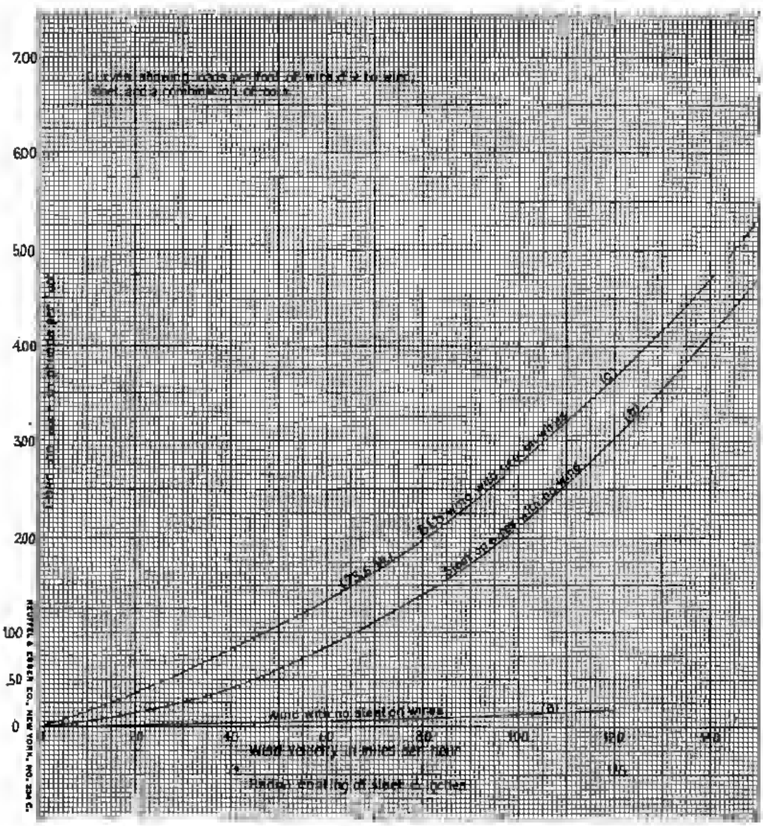

Fig. 3

The moment about the ground line section, due to the vertical loads is practically negligible due to the fact that the greater part of the weight of the pole, fixtures and attachments is balanced and therefore produces no moment upon the pole. Any small unbalanced weight acts through such a short lever arm that it produces a very small moment upon the pole. In any particular storm loading

area, therefore, the pole should be designed to resist only the transverse load corresponding to that area. In calculating this load, the wind pressure is considered as acting upon the projected areas of the pole and of the ice-coated wires, strand, etc., for 1/2 of each adjacent span.

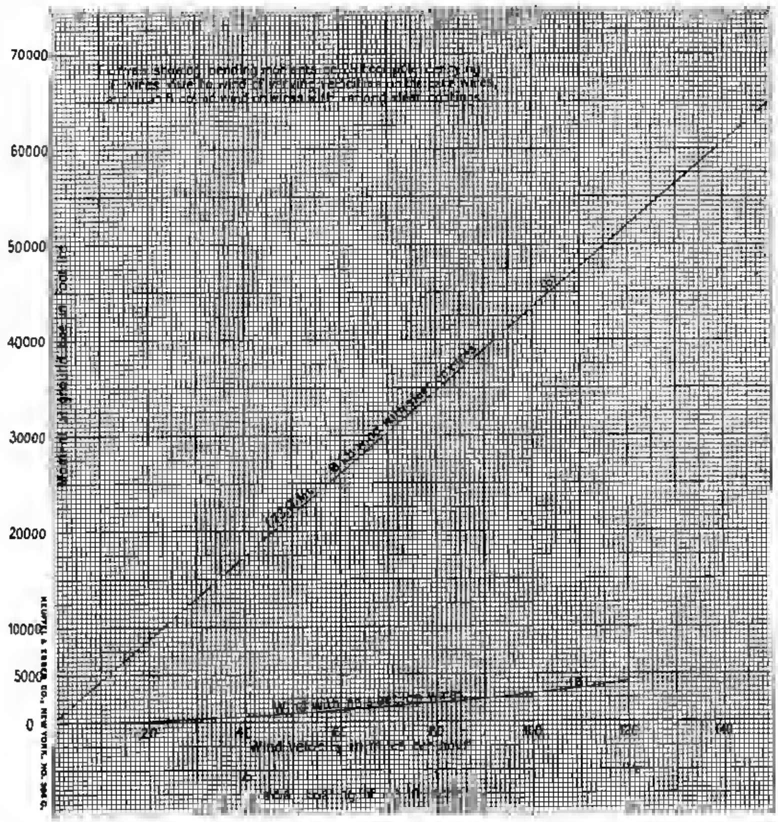

Fig. 4

Fig. 4 shows the relative magnitude of the bending moments at the ground line of a 25-foot pole carrying 10 wires, caused by (a) winds of various velocities with no ice on the wires, and (b) an 8-pound wind with various ice coatings on the wires. In the case of the pole design, it is evident that the wind pressure on the increased "sail area" created by the ice on the wires represents the predominant portion of the storm load.

There are in the Bell System approximately 14 million poles, carrying nearly 4 million miles of open wire of which it is estimated that about 9½ million poles and 2½ million miles of wire are located in what is known as the heavy loading area, some 2½ million poles and over 700,000 miles of wire in the medium area and about 2 million poles and nearly 600,000 miles of wire in the light or no sleet area. Nearly 70 per cent of the poles and aerial wire in the Bell System are, therefore, periodically exposed to storms of heavy loading intensity against which they must be designed, constructed and maintained in order that there may be minimum interruption of service consistent with the practicable and economical design of the plant as a whole.